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For: Method and Device for Generating Multi-Functional Feedback

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SIR:

In order to complete the claim to priority in the above-identified application under 35 U.S.C. §119, enclosed herewith is the certified documentation as follows:

Application No. **20012187,** filed on November 12, 2001, in Finland, upon which the priority claim is based.

Respectfully submitted,

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E T U O I K E U S T O D I S T U S
P R I O R I T Y   D O C U M E N T

Hakija Applicant	**Myorigo Oy** **Oulu**
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"Method and device for generating feedback"
(Menetelmä ja laite takaisinkytkennän muodostamiseksi)

Täten todistetaan, että oheiset asiakirjat ovat tarkkoja jäljennöksiä Patentti- ja rekisterihallitukselle alkuaan annetuista selityksestä, patenttivaatimuksista, tiivistelmästä ja piirustuksista.

This is to certify that the annexed documents are true copies of the description, claims, abstract and drawings originally filed with the Finnish Patent Office.

Pirjo Kaila
Tutkimussihteeri

Maksu 50 €
Fee 50 EUR

Maksu perustuu kauppa- ja teollisuusministeriön antamaan asetukseen 1027/2001 Patentti- ja rekisterihallituksen maksullisista suoritteista muutoksineen.

The fee is based on the Decree with amendments of the Ministry of Trade and Industry No. 1027/2001 concerning the chargeable services of the National Board of Patents and Registration of Finland.

METHOD AND DEVICE FOR GENERATING FEEDBACK

FIELD OF THE INVENTION

The present invention relates to electronic devices. In particular, the present invention relates to a novel and improved method, a dynamic user interface and an electronic device for generating user detectable multi-functional feedback.

BACKGROUND OF THE INVENTION

In information technology, the user interface (UI) is everything designed into an information device with which a human being may interact, including display screen, keyboard, mouse, light pen, the appearance of a desktop, illuminated characters, help messages, and how an application program or a Web site invites interaction and responds to it. In early computers there was very little user interface except for a few buttons at an operator's console. The user interface was largely in the form of punched card input and report output.

Personal Digital Assistants (PDA) typically comprise a large display area in proportion to the size of the device. Most PDAs include only a few mechanical buttons in order to provide as large display area as possible. Therefore, the display area is also used as an input device. The display area is usually touch-sensitive so that information can be transferred into the device just by touching the display or using a special tool, e.g. a special pen.

U.S. Patent 5,241,308 (Paragon Systems) describes a touch sensitive panel for generating selected ones of any of a plurality of different signals, each of which is generated by touching a different location on the panel. The apparatus includes also force sensing means for sensing the magnitudes of the forces that are applied to each panel member support

by the panel member when the member is touched at a selected location.

Touch-sensitive displays have many advantages over conventional information input methods. The display size can be made bigger when only few mechanical buttons are present. Above all, all the needed buttons can be generated by program basis in an applicable place. There are, however, several problems when a touch-sensitive display is used as a primary information input device. When a user uses his/her finger to touch the display, the problem is that the user does not necessarily receive any haptic feedback as to whether his/her selection is acceptable or whether the selection is made at all. A traditional keyboard always gives some kind of mechanical response to a press of a button.

The main problem is that there is no solution for electronic devices for generating feedback for various stimulus signals with a single integrated component, the following conditions being fulfilled:

- Cost-effective solution, and
- Minimal power consumption.

U.S. Patent No. 5,245,245 (Motorola) describes an electronic device comprising a piezo-bender. The device is preferably a pager. When a signal is received, an electrical drive circuit electrically coupled to the piezo-bender drives the piezo-bender with a drive signal to generate vibratory motion in the piezo-bender, and a vibratory alert is thus provided. The device comprises also tuning means slidably coupled to the piezo-bender for mechanically tuning the resonance frequency of vibration of the piezo-bender by varying the length of the piezo-bender that can vibrate. It must be noted that the piezo-bender is mechanically tuned so the tuning must be made by a competent technician. It is also difficult to manufacture devices with exactly same (resonance)

characteristics because of the mechanical tuning feature.. The solution in U.S. Patent No. 5,245,245 is also bound to a certain fixed resonance frequency. U.S. Patent No. 5,245,245 represents a low-profile and reliable vibrator for a selective call receiver. However, the reference publication does not present any connection between user actions and vibratory alert. The solution is not applicable for generating feedback for various stimulus signals with a single integrated component.

Reference publication WO01/54109 (Immersion) represents a solution of haptic feedback for touchpads and other touch controls. In the publication, a user uses a touch-input device for entering control instructions. Moreover, at least one actuator is coupled to the touch input device and outputs a force to provide a haptic sensation to the user contacting the touch surface. In other words, the user receives feedback from the input device itself. The actuator is situated under the touch-sensitive display. The problem is that the solution presented in the reference publication is not applicable for generating feedback for various stimulus signals with a single integrated component.

The expression "touch-sensitive display" refers preferably to such displays that are being used in current PDAs. These displays, however, have weaknesses. The display is vulnerable to external impacts. The display may also be temperature sensitive, i.e. the use of a device with a touch-sensitive display may be restricted to a certain temperature range.

SUMMARY OF THE INVENTION

The present invention describes a method and an electronic device for generating user detectable multi-functional feedback with a single component in response to a stimulus signal. In the preferred em-

bodiment, the electronic device is a hand-held device comprising at least a housing, electronic circuitry located in said housing, a display, said housing comprising at least a partially transparent lens, the transparent lens area covering at least the display.

The electronic device in the present invention comprises one or more resonating vibrating elements attached to the housing or on the electronic circuitry. In a preferred embodiment, one or more resonating vibrating elements are attached to an area of the lens not covering the display. The lens is not necessarily a touch-sensitive display as represented in the background of the invention section. Instead, the lens may be more like a panel where the lens itself is not touch-sensitive. When the resonating element(s) are attached to the lens, the feedback is transmitted to the user of the electronic hand-held device effectively through the lens. With the resonating vibrating elements, the feedback is produced to the user in response to the stimulus signal. The resonating vibrating element is preferably a piezo-electric bender.

The touch-sensitive feature is achieved with special detecting means. In a preferred embodiment, the detecting means refer to one or more force sensors attached to the lens. In one embodiment, the electronic device comprises at least force sensors with which the location of a touch on the display can be determined.

In the present invention, an electrical drive circuit is electrically coupled to the resonating vibrating element(s) for electrically driving the resonating vibrating element(s) with a drive signal. The drive signal is constituted based on the stimulus signal. The stimulus signal is preferably a user-actuated signal, a radio signal received with a radio receiver of said electronic device or an electronic device in-

duced signal. It is also possible that one or more different stimulus signals are detected at the same time. When the drive signal is supplied in the resonating vibrating elements, preferable one or more of the following feedback signals are generated: a haptic feedback signal, a vibratory alert signal, an audio signal or a buzzer signal.

The present invention describes also a dynamic user interface for generating user detectable multi-functional feedback with a single component in response to a stimulus signal in a device, the user interface comprising at least a housing and electronic circuitry located in the housing. The dynamic user interface further comprises means for detecting the stimulus signal, one or more resonating vibrating elements attached to the housing or on the electronic circuitry, and an electrical drive circuit electrically coupled to the resonating vibrating element(s) for electrically driving the resonating vibrating element(s) with a drive signal, the drive signal being constituted based on the stimulus signal.

The present invention has several advantages over the prior-art solutions. In the present invention, the resonating vibrating element(s) may be used in several different functions. In the prior-art solutions, each function requires a dedicated component in the implementation. This is a clear advantage.

The present invention represents a solution where the power consumption is low. This is a very important feature in electronic hand-held devices. In the prior-art solutions, each feedback signal (a haptic feedback signal, a vibratory alert signal, an audio signal or a buzzer signal) is generated with a dedicated component. In the present invention, all the afore-mentioned feedback signals are generated with a single component, and therefore, there is only one

power-consuming component. This enables easier minimisation of the power consumption.

The present invention describes also a solution where it is not necessary to use conventional touch-sensitive displays. Electronic hand-held devices can be made much more durable because it is not necessary to use any elastic membranes or touch-sensitive displays. Instead, a rigid transparent lens covers the actual display device.

The solution represented in the present invention is simple. Further, the present invention is not prone to manufacturing differences because the feedback can be adjusted easily.

The present invention has still further advantages. Because the solution uses only single component to generate feedback, this means significant space saving in the Printed Circuit Board (PCB). The number of components needed on the PCB is thus reduced. The solution represented in the present invention is also a low-cost solution because of the savings in the components.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are included to provide a further understanding of the invention and constitute a part of this specification, illustrate embodiments of the invention and together with the description help to explain the principles of the invention. In the drawings:

Fig 1 is a simplified block diagram of an electronic hand-held device, according to the present invention,

Fig 2 is a top plan view of an electronic hand-held device, according to the present invention,

Fig 3 is a graph illustrating the resonance frequency, according to the present invention, and

Fig 4 is a side view of a parallel type mass-loaded piezo-bender, according to the preferred embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Reference will now be made in detail to the embodiments of the present invention, examples of which are illustrated in the accompanying drawings.

Figure 1 is an electrical block diagram of an electronic hand-held device, e.g. a Personal Digital Assistant (PDA) or a mobile phone. Figure 1 does not comprise all the elements required in the electronic hand-held device but only the relevant elements required in the present invention. The electronic hand-held device comprises a central processing unit CPU for controlling the electronic hand-held device. A memory MEM is associated with the CPU to store relevant software applications and other relevant information. The electronic hand-held device comprises at least a partially transparent lens TP, the transparent lens area covering at least the display. Also the term touch panel can be used when referring to the lens. The actual display DSP is located under the transparent lens TP area.

The lens TP is also used as a primary input device. User actions are detected with means IM for detecting stimulus signals. Means IM for detecting in one embodiment refers preferably to force sensors PS attached directly or indirectly to the lens TP. With three force sensors any location (a touch) on the lens TP area can be recognised and a relevant procedure started. Means IM for detecting stimulus signals together with the lens TP and the display DSP may refer to a conventional touch-sensitive display. In general, means IM for detecting stimulus signals may refer to

several different physical or software components with which the stimulus signal(s) can be detected.

Figure 1 also comprises a drive circuit DC and vibrating element(s) VIB. The drive circuit (DC) is electrically coupled to said resonating vibrating element(s) (VIB) and electrically drives the resonating vibrating element(s) (VIB) with a drive signal, the drive signal being constituted based on the stimulus signal. A vibrating element is preferably a piezo-electric element attached directly to the lens TP. The CPU controls the drive circuit DC which itself supplies a drive signal to the vibrating element(s) VIB. The piezo-electric element is attached to the lens TP, e.g. by gluing, welding, screwing etc.

The CPU comprises means DM for determining the source of the stimulus signal, means TM for determining the resonance frequency by producing a bursted frequency sweep, means LM for detecting the vibration level with said force sensors PS, and means OM for feeding the obtained frequency to the resonating vibrating element(s) VIB. The above mentioned means are preferably implemented with the CPU and/or relevant software application(s).

The drive circuit DC in one embodiment comprises several components. It can comprise, e.g. an analog to digital converter (A/D), a digital signal processor, a digital to analog converter (D/A) and an amplifier. When, e.g. a radio signal is received with the radio receiver RF, the radio signal is input to a digital signal processor. The digital signal processor processes the radio signal and inputs the signal to the D/A-converter. The analog signal is then amplified with the amplifier and finally the amplified signal is input to the piezo-bender. Because the piezo-bender is attached to the lens TP, the whole system acts like an audio speaker and is able to produce an audio signal.

In one embodiment of Figure 1, the vibrating element, e.g. a piezo-bender, is used as means IM for detecting the user stimulus signal. Therefore, both detecting the user stimulus signal and generating a feedback signal is produced by an integrated component.

In one embodiment, the piezo-bender is also used in measuring acceleration. Preferably there is an external mass attached to the piezo-bender. When a hand-held device comprising a mass attached piezo-bender is moved along the z-axis, the z-axis being essentially perpendicular to the x/y-plane of the display of the hand-held device, the piezo-bender measures force changes (acceleration) resulting from the inertia. Several functions can be linked to the measurement. One example is that the zooming factor of the material on the display of the hand-held device depends on the measured acceleration information. The zooming example is described in more detail in the patent application WO0127735 (Myorigo).

If the electronic hand-held device is a mobile phone and/or a radio, the device comprises also a radio receiver RF part for sending and receiving radio frequency signals.

Figure 2 is a top plan view of an electronic hand-held device HD. The device is preferable a Personal Digital Assistant (PDA) or a mobile phone. Figure 2 is a simplified example of an electronic hand-held device so the device may comprise also other features or functional buttons. The electronic hand-held HD device comprises a housing HS. The housing HS comprises at least a partially transparent lens TP covering the actual display DSP.

In a preferred embodiment, the lens/touch panel TP itself is not touch-sensitive. The force sensors PS are directly or indirectly attached to the lens TP. In Figure 2 there are three force sensors PS

attached to the lens TP. The force sensors PS are in a preferred embodiment attached to the housing HS as in a triangular form. The force sensors PS can be attached in any other appropriate way.

With three or more force sensors PS it is possible to accurately calculate and determine a place where the lens TP is touched. With the above-mentioned arrangement, the lens TP itself does not have to contain any touch-sensitive membrane or any other touch-sensitive features. Instead, a touch is detected with the force sensors PS. The force sensors can sense a user input also outside the transparent lens area. Therefore, certain areas of the housing HS or non-transparent areas of the lens TP can also be used as a part of the user interface.

Figure 2 comprises also a resonating vibrating element VIB. The resonating vibrating element VIB is attached to an area of the lens TP not covering the display DSP. The lens TP is preferably impervious outside the display DSP area. The vibrating element VIB is preferably a piezo-electric element and is of unimorph, bimorph or multilayer structure. The multilayer structure is the preferred solution because of the low input voltage required. The piezo-bender is preferably formed of three parts: an upper part, a lower part and a metal element between those parts. The metal element significantly strengthens the overall structure. The drive circuit DC of Figure 1 applies the desired drive signal to the resonating vibrating element VIB, thus causing the vibrating element VIB to vibrate/resonate at a certain frequency.

In one embodiment of Figure 2, the resonating vibrating elements are used to provide multiple feedback signals. The resonating vibrating element is preferably a piezo-bender of unimorph, bimorph or multilayer structure. The stimulus signal can originate from different sources. The stimulus signal can be a

user-actuated signal, e.g. a touch on the lens. It can also be a radio frequency signal received with the radio receiver of the electronic device. This is the case when the electronic device is, e.g. a mobile phone. Alternatively, the stimulus signal can be an electronic device induced signal, e.g. operating system originated signal. Therefore, each stimulus signal may cause a different feedback signal.

When the piezo-bender is used to response to, e.g. a touch on the lens, a pulsed or continuous haptic feedback signal occurs. The haptic feedback signal is typically a short signal, e.g. 200-300 Hz of frequency and, e.g. 5-100 ms of duration, or a continuous signal. This signal is typically a plain or modulated resonance frequency of the piezo-bender. However, the feedback signal does not have to be restricted only to the haptic feedback. With a piezo-bender, practically any required frequency bandwidth can be produced. The feedback signal can additionally be a buzzer signal, a vibratory alert signal or an audio signal. This means that a piezo-bender attached to the lens of the electronic hand-held device can act as a speaker. Producing of an audio signal may require that the audio bandwidth is flattened by digital signal processing in order to reduce the effect of the cantilever resonance frequencies. Certain criteria must be satisfied when generating audio signals. Especially in the buzzer feature, the sound pressure level (in Pascals) has to be adequate. The frequency band has to be broad enough. Also the harmonic multifold frequencies of the resonance frequency can be made use of when generating the feedback signal.

A conventional electronic device comprises different components for generating a haptic feedback signal, a buzzer signal, a vibratory alert signal or an audio signal. A buzzer signal is generated with a buzzer, an audio signal is generated, e.g. with a

speaker, a vibratory alert signal is generated, e.g. with an electromagnetic motor and a haptic feedback signal, e.g. with a DC motor, a solenoid, moving magnet actuator etc. All the above-mentioned feedback signals can be generated with the piezo-element in the present invention. This means significant decrement in the power consumption compared to the situation, where the feedback signals are generated with separate components.

Figure 1 and 2 represents only one embodiment of the dynamic user interface described in the present invention. The dynamic user interface is not restricted to any special devices. The dynamic user interface is able to generate user detectable multifunctional feedback with a single component in response to a stimulus signal. The stimulus signal can be a user actuated signal, a radio signal received with a radio receiver or a device induced signal. The user interface comprises at least a housing and electronic circuitry located in the housing. The shape of the housing is not restricted. With means for detecting the stimulus signal a stimulus signal source is defined. One or more resonating vibrating elements is attached to the housing or on the electronic circuitry, e.g. a PCB board located in the housing. An electrical drive circuit electrically coupled to the resonating vibrating element(s) electrically drives the resonating vibrating element(s) with a drive signal, the drive signal being constituted based on the stimulus signal.

The resonating vibrating element is preferably a piezo-bender of unimorph, bimorph or multilayer structure. It is very crucial to define the type of the stimulus signal, because the feedback signal generated by the piezo-bender solely depends on the stimulus signal. The feedback signal is a haptic feedback signal, a vibratory alert signal, an audio signal

or a buzzer signal. It is very important to carefully define the attachment point of the piezo-bender to the housing or to the electronic circuitry. The piezo-bender component itself does not produce all the needed feedback signals but attached to the housing of to the electronic circuitry it is able to produce multi-functional feedback.

There are numerous devices where the dynamic user interface described can be used. The devices include, e.g. joysticks, keyboards, e-books, or practically any device, where multi-functional feedback can be used.

Figure 3 shows the acceleration and the current-frequency response of an exemplary electronic hand-held device. The upper graph represents the acceleration factor of the lens as a function of frequency. The bigger the acceleration value, the stronger the feedback to the user. The lower graph represents the current as a function of frequency. In a preferred embodiment of Figure 3, an external mass is attached to the vibrating element. The use of an external mass increases the force obtained at the clamp point of the piezo-bender and also improves the low-frequency audio bandwidth. The reason why the frequency area for a haptic feedback is quite low, e.g. 200-300 Hz, is that normally a human being is not so sensitive to higher frequencies, e.g. with a hand. The peak current value is slightly higher in the resonance than in the immediate surroundings of the resonance frequency. The acceleration and the current values in Figure 3 are not necessarily real values but merely exemplary values.

The resonance frequency can be made use of yet another way. In the manufacturing phase, the lens or the overall housing may be manufactured in such a way that one of the resonance frequencies of the lens or of the housing is in the same frequency range as

that of the vibrating element. Therefore, the overall effect of the haptic feedback is more efficient.

It may occur that the resonance frequency must be individually seeked. The electronic hand-held device comprises a feature where the optimal frequency may be determined. This is done by determining the resonance frequency by producing a bursted frequency sweep. The force sensors can be made use of in another situation. The responses of the vibrating element(s) (haptic feedback) can be detected with the force sensors. With the force sensors it is possible to determine the individual resonance frequency. When the measurement is made, the drive circuit is set to feed the obtained frequency to the vibrating element(s).

The feedback parameters can also be individually tuned for each person using it. The main parameters that the user can control are, for example:

- amplitude
- the time period of the vibration
- the vibration frequency.

Figure 4 is a side view of a parallel type mass-loaded piezo-bender, according to the preferred embodiment of the present invention. Here, the metal beam 42 is placed between the piezo-ceramic layers 41 and 43. The metal beam 42 extends beyond the piezo-ceramic layers 41 and 43 and has a mass 44 mechanically coupled to the other end of the metal beam 42. The mass 44 may be spot welded to the metal beam 42, and provides a vibratable body at one end of the cantilever structure. The other end of the piezo-bender is clamped to the lens or housing 45. When an electrical driving signal is applied, for example, across the opposing surfaces of the piezo layers, the tip of the piezo-bender begins to deflect. The deflections at the resonance of the piezo-bender are significantly greater than without the mass because of the extension of the metal beam 42 beyond the piezo-ceramic layers

41 and 43 and because of the mass 44 at the end of the beam 42. The vibrating mass 44' and vibrating bender tend to impart greater impulses to the lens or housing 45 through each vibration cycle. In the present invention, the resonating vibrating elements are made use of in several different functions. In the prior-art solutions, each function requires a dedicated component in the implementation. Therefore, valuable space saving in electronic hand-held devices is accomplished, and above all, the power consumption is minimized. This is a very important feature in electronic hand-held devices.

The present invention describes also a solution using only single component to generate feedback. This means significant space saving in the Printed Circuit Board (PCB). The number of components needed on the PCB is reduced. The solution represented in the present invention is also a low-cost solution because of the savings in the components.

The present invention describes a solution where feedback can be adjusted electrically. Adjusting the drive signal a desired feedback can be achieved. The adjustment can be set manually by the user or automatically by the device itself. The present invention describes also a dynamic user interface and an integrated low-cost and low power solution for producing multi-functional feedback.

It must be noted that the piezo-bender component itself is not necessarily able to generate all the feedback signals (a haptic feedback signal, a buzzer signal, a vibratory alert signal or an audio signal) described in the present invention. However, the situation is different when the piezo-bender is attached, e.g. to a lens, a certain part of a housing, or a PCB board. Together with the component on which the piezo-bender is attached, it is possible to gener-

ate multi-functional feedback as described in the present invention.

It is obvious to a person skilled in the art that with the advancement of technology, the basic idea of the invention may be implemented in various ways. The invention and its embodiments are thus not limited to the examples described above, instead they may vary within the scope of the claims.

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CLAIMS

1. An electronic device for generating user detectable multi-functional feedback with a single component in response to a stimulus signal, said electronic device (HD) comprising at least a housing (HS) and electronic circuitry located in said housing (HS),

c h a r a c t e r i s e d in that said electronic device further comprises:

means (IM) for detecting said stimulus signal;

one or more resonating vibrating elements (VIB) attached to said housing (HS) or on said electronic circuitry; and

an electrical drive circuit (DC) electrically coupled to said resonating vibrating element(s) (VIB) for electrically driving said resonating vibrating element(s) (VIB) with a drive signal, said drive signal being constituted based on said stimulus signal.

2. The electronic device according to claim 1, c h a r a c t e r i s e d in that the electronic device comprises a display (DSP) and a partially transparent lens (TP), the transparent lens area covering at least said display (DSP), said resonating vibrating element(s) (VIB) being attached to an area of said lens (TP) not covering said display (DSP).

3. The electronic device according to claim 1 or 2, c h a r a c t e r i s e d in that said stimulus signal is one or more of the following signals:

a user actuated signal;

a radio signal received with a radio receiver (RF) of said electronic device; and

an electronic device induced signal.

4. The electronic device according to any of the claims 1, 2 or 3, c h a r a c t e r i s e d in that said feedback comprises one or more of the following signals:

a haptic feedback signal;

a vibratory alert signal;

an audio signal; and

a buzzer signal.

5. The electronic device according to any of the claims 1, 2, 3 or 4, characterised in that the means (IM) for detecting said stimulus signal comprises one or more sensors (PS) for detecting user input.

6. The electronic device according to any of the claims 1, 2, 3, 4 or 5, characterised in that the electronic device comprises means (DM) for determining the source of said stimulus signal.

7. The electronic device according to any of the claims 1, 2, 3, 4, 5 or 6, characterised in that the electronic device comprises:

means (TM) for determining the resonance frequency by producing a bursted frequency sweep;

means (LM) for detecting the vibration level with said sensor(s) (PS); and

means (OM) for feeding the obtained frequency to said resonating vibrating element(s) (VIB).

8. The electronic device according to any of the claims 1, 2, 3, 4, 5, 6 or 7, characterised in that said resonating vibrating element (VIB) is used as an acceleration sensor.

9. The electronic device according to any of the claims 1, 2, 3, 4, 5, 6, 7 or 8, characterised in that said resonating vibrating element (VIB) is a piezo-bender of a unimorph, bimorph or multilayer structure.

10. The electronic device according to claim 9, characterised in that the electronic device comprises an external mass attached to said piezo-bender.

11. The electronic device according to claim 1 or 2, characterised in that said housing (HS) and/or said lens (TP) is manufactured so that at least one of its resonating frequencies is within the

same frequency range as the frequency range of said resonating vibrating element(s) (VIB).

12. The electronic device according to any of the claims 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 or 11, characterised in that the electronic device is a hand-held electronic device.

13. A method for generating user detectable multi-functional feedback with a single component in response to an stimulus signal with an electronic device, said electronic device comprising at least a housing and electronic circuitry located in said housing,

characterised in that said electronic device comprises one or more resonating vibrating elements attached to said housing or on said electronic circuitry, the method further comprising the steps of:

detecting said stimulus signal; and

electrically driving said resonating vibrating element(s) with a drive signal with an electrical drive circuit electrically coupled to said resonating vibrating element(s), said drive signal being constituted based on said stimulus signal.

14. The method according to claim 13, characterised in that the electronic device comprises a display and a partially transparent lens, the transparent lens area covering at least said display, said resonating vibrating element(s) being attached to an area of said lens not covering said display.

15. The method according to claim 13 or 14, characterised in that said stimulus signal comprises one or more of the following signals:

a user actuated signal;

a radio signal received with a radio receiver of said electronic device; and

an electronic device induced signal.

16. The method according to any of the claims 13, 14 or 15, characterised in that said feedback comprises one or more of the following signals:

a haptic feedback signal;
a vibratory alert signal;
an audio signal; and
a buzzer signal.

17. The method according to any of the claims 13, 14, 15 or 16, characterised in that detecting user input with one or more sensors.

18. The method according to any of the claims 13, 14, 15, 16 or 17, characterised in that the method comprises the step of:

determining the source of said stimulus signal.

19. The method according to any of the claims 13, 14, 15, 16, 17 or 18, characterised in that the method comprises the steps of:

determining the resonance frequency by producing a bursted frequency sweep;

detecting the vibration level with said sensor(s); and

feeding the obtained frequency to said resonating vibrating element(s).

20. The method according to any of the claims 13, 14, 15, 16, 17, 18 or 19, characterised in that using said resonating vibrating element as an acceleration sensor.

21. The method according to any of the claims 13, 14, 15, 16, 17, 18, 19 or 20, characterised in that said resonating vibrating element is a piezo-bender of a unimorph, bimorph or multilayer structure.

22. The method according to claim 21, characterised in that the method comprises the step of:

attaching an external mass to said piezo-bender.

23. The method according to any of the claims 13, 17, 21 or 22, characterised in that detecting said stimulus signal with said piezo-bender.

24. The method according to claim 12 or 13, characterised in that the method comprises the step of:

manufacturing said housing and/or said lens so that at least one of its resonance frequencies is within the same frequency range as the frequency range of said resonating vibrating element(s).

25. The method according to any of the claims 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23 or 24, characterised in that the electronic device is a hand-held electronic device.

26. A dynamic user interface for generating user detectable multi-functional feedback with a single component in response to a stimulus signal in a device, said user interface comprising at least a housing (HS) and electronic circuitry located in said housing (HS),

characterised in that said dynamic user interface further comprises:

means (IM) for detecting said stimulus signal;

one or more resonating vibrating elements (VIB) attached to said housing (HS) or on said electronic circuitry; and

an electrical drive circuit (DC) electrically coupled to said resonating vibrating element(s) (VIB) for electrically driving said resonating vibrating element(s) (VIB) with a drive signal, said drive signal being constituted based on said stimulus signal.

27. The dynamic user interface according to claim 26, characterised in that the device comprises a display (DSP) and a partially transparent lens (TP), the transparent lens area covering at least said display (DSP), said resonating vibrating ele-

ment(s) (VIB) being attached to an area of said lens (TP) not covering said display (DSP).

28. The dynamic user interface according to claim 26 or 27, c h a r a c t e r i s e d in that said stimulus signal is one or more of the following signals:

a user actuated signal;

a radio signal received with a radio receiver (RF); and

a device induced signal.

29. The dynamic user interface according to any of the claims 26, 27 or 28, c h a r a c t e r i s e d in that said feedback comprises one or more of the following signals:

a haptic feedback signal;

a vibratory alert signal;

an audio signal; and

a buzzer signal.

30. The dynamic user interface according to any of the claims 26, 27, 28 or 29, c h a r a c t e r i s e d in that the means (IM) for detecting said stimulus signal comprises one or more sensors (PS) for detecting user input.

31. The dynamic user interface according to any of the claims 26, 27, 28, 29 or 30, c h a r a c t e r i s e d in that the dynamic user interface comprises means (DM) for determining the source of said stimulus signal.

32. The dynamic user interface according to any of the claims 26, 27, 28, 29, 30 or 31, c h a r a c t e r i s e d in that the dynamic user interface comprises:

means (TM) for determining the resonance frequence by producing a bursted frequency sweep;

means (LM) for detecting the vibration level with said sensor(s) (PS); and

means (OM) for feeding the obtained frequency to said resonating vibrating element(s) (VIB).

33. The dynamic user interface according to any of the claims 26, 27, 28, 29, 30, 31 or 32, characterised in that said resonating vibrating element (VIB) is used as an acceleration sensor.

34. The dynamic user interface according to any of the claims 26, 27, 28, 29, 30, 31, 32 or 33, characterised in that said resonating vibrating element (VIB) is a piezo-bender of a unimorph, bimorph or multilayer structure.

35. The dynamic user interface according to claim 34, characterised in that the dynamic user interface comprises an external mass attached to said piezo-bender.

36. The dynamic user interface according to claim 26 or 27, characterised in that said housing (HS) and/or lens (TP) is manufactured so that at least one of its resonating frequencies is within the same frequency range as the frequency range of said resonating vibrating element(s) (VIB).

37. The dynamic user interface according to any of the claims 26, 27, 28, 29, 30, 31, 32, 33, 34, 35 or 36, characterised in that the device is a hand-held electronic device.

(57) ABSTRACT

The present invention describes a method, a dynamic user interface and an electronic device for generating user detectable multi-functional feedback with a single component in response to a stimulus signal. In the invention, one or more resonating vibrating element(s), e.g. piezo-bender, are attached to a certain component of the device. A conventional electronic device comprises different components for generating a haptic feedback signal, a buzzer signal, a vibratory alert signal or an audio signal. All the above-mentioned feedback signals can be generated with the piezo-element attached to, e.g. a lens or a housing. This means significant decrement in the space needed and in the power consumption compared to the situation, where the feedback signals are generated with separate components.

(FIG. 2)

L5

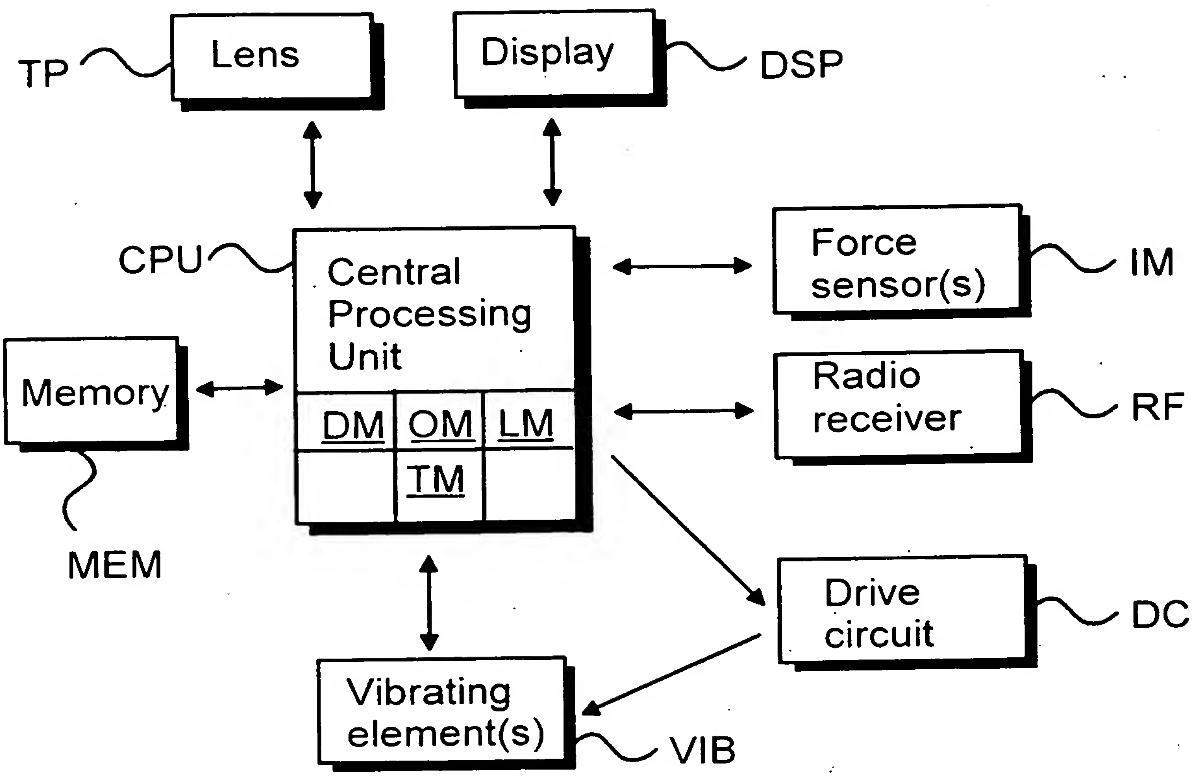

Lens
TP
Display
DSP
CPU
Central Processing Unit
DM
OM
LM
TM
Force sensor(s)
IM
Radio receiver
RF
Memory
MEM
Drive circuit
DC
Vibrating element(s)
VIB

Fig. 1

L5

2

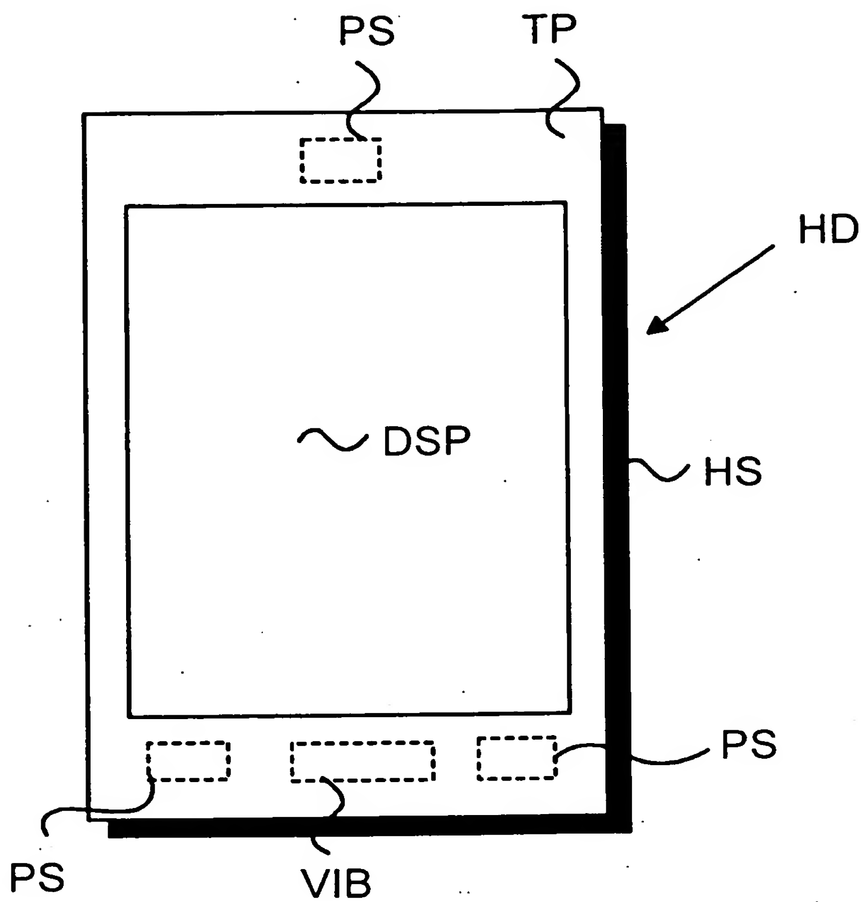
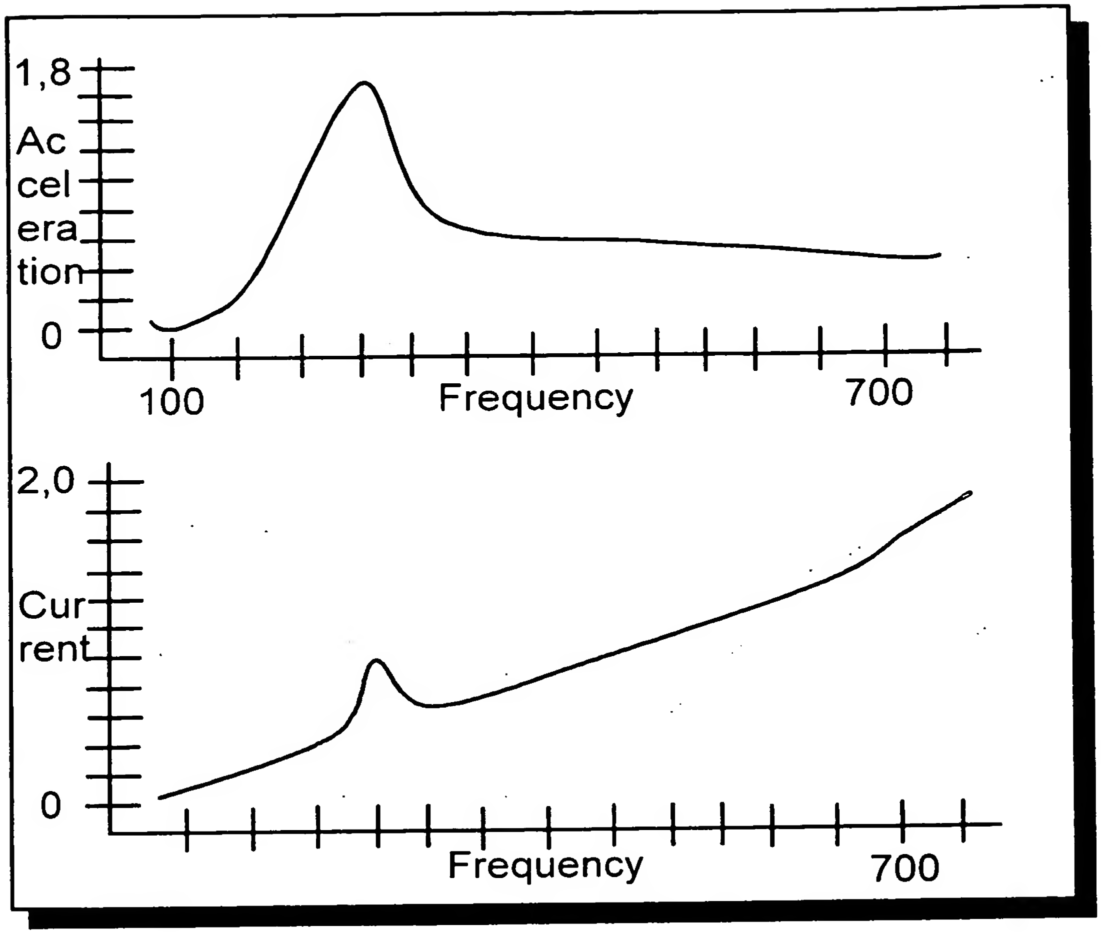


Fig. 2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100
Frequency
700
2,0
Cur
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0
Frequency
700

Fig. 3

i5 4

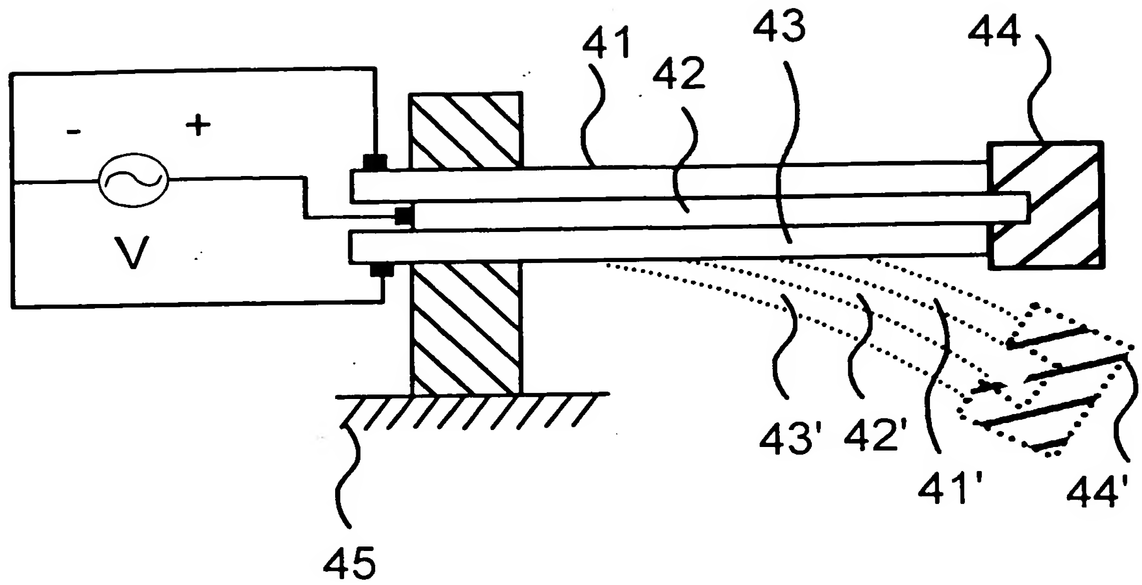

Fig. 4